Development and Implementation of a Graphical User Interface to Examine Land-Use Planning Efforts in Licking County, Ohio[1]

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ABSTRACT. A Graphical User Interface (GUI) was developed in ARC/INFO to provide land-use planners and land owners with a user-friendly tool to access and query a digital database on various planning issues or concerns in Licking County. Planners from Licking County and the Resource Analysis Section (RAS) at the Ohio Department of Natural Resources (ODNR) were surveyed to identify the essential data layers needed to address each agency's specific planning initiatives. Two case studies were developed to implement the GUI. The first case study is theory based and involves an examination of potential sites for conservation tillage practices on potentially highly erodible land. The second case study is a real-world application, derived from an interest expressed by planners from both agencies to identify potential large-scale development sites within the county. The overall performance of the GUI was evaluated by land-use planners that found the interface more user-friendly and efficient than manual techniques.

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INTRODUCTION

Over the last several decades, Geographic Information Systems (GIS) have become increasingly important as a tool applied to scientific research. At the national level, many of the organizations that monitor agriculture and land-use planning have acquired GIS technology. Locally, GIS has been integrated with land-use planning efforts at the county planner's level. It is at this level that the use of GIS technology may lead to more innovative ways of addressing land-use concerns and have a far-reaching impact on the monitoring and rehabilitation of degraded lands. The rapid adoption of GIS as a planning tool is largely due to the range and breadth of capabilities that permit users to interactively display and access spatial information from several sources.

Until recently, natural resource and land-use planners made planning decisions based on data without necessarily having a comprehensive understanding of the spatial and temporal components. Advances in GIS technology provide a framework within which temporal databases can be joined with spatial data to evaluate trends or patterns for a given area across time and space. Currently, difficulty of use is perceived as the largest single impediment to the overall acceptance and expanded use of GIS (Steyaert 1996). Many potential users view GIS technology as overly complicated, requiring a level of expertise that is beyond their current technical capabilities.

Planners from Licking County and the Ohio Department of Natural Resources (ODNR) identified the need for training on the use and capabilities of GIS primarily because many of the planners have little, if any, experience operating the hardware and software relevant to this technology. Their supervisors plan to purchase GIS software but do not intend to hire additional, experienced staff. The current prevailing attitude is to learn how to use the software by "playing" or practicing with a tutorial. There is a degree of frustration on the part of some planners because, in addition to their daily routines, they are now expected to learn new technical tools. This situation is further exacerbated by the fact that many agencies often do not have access to resources such as an information or systems specialist who can answer questions regarding the use and capabilities of the hardware and GIS software.

The design of a user-friendly Graphical User Interface (GUI) can provide land-use planners with a viable tool to address specific planning concerns, resulting in quick identification and analysis of selected features and characteristics that can be used to implement better management practices and support decision-making processes regarding land management. Within this context, a GUI called Minlayer was developed within a GIS framework (ARC/INFO) to provide land-use planners, land owners, and other interested users with a user-friendly tool to query a digital database on various planning issues or concerns, and to graphically visualize the spatial and temporal relationships.

Planners from Licking County and the Resource Analysis Section (RAS) in the Division of Real Estate and Land Management (REALM) at the Ohio Department of Natural Resources (ODNR) were surveyed to identify the essential data layers needed to address each agency's specific planning initiatives. Two case studies were developed to implement the GUI. The first case study is theory based and involves an examination of potential sites for conservation tillage practices on potentially highly erodible land. The second case study is a real-world application that focuses on determining large-scale development sites within Licking County. Large-scale development is defined as sites where large, heavy, industrial and commercial structures can be constructed (Lewis 1991, Lewis 1992, Crecelius 1982). The overall purpose of this interface was to develop a spatial tool that planners can use to identify and access the digital layers required to address specific planning concerns defined in both case studies while adhering to budget and time constraints.

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LITERATURE REVIEW

The planning process can be supported and improved by an automated system through which geospatial data can be entered, manipulated, and analyzed (Lull and others 1995). Geographic Information Systems (GIS) are computer-based tools designed to capture, manipulate, process, analyze, display, and store georeferenced data (Federa 1993). These integrated capabilities, coupled with temporal and spatial components, allow for the simulation of real-world complexities (Matson and others 1995).

Spatial data, or geospatial or geographic data, are defined as data that are geographically referenced to locations that are on the surface of the earth (Goodchild 1996). Primary issues that must be addressed in any extensive application of spatial data include data accuracy and the modeling of error. Spatially referenced data are a fundamental component of any GIS and are an essential part of any integrated agricultural model (Federa 1993). A spatially-referenced database can use the computational power of a GIS. In addition, a GIS can use the spatial-referenced database to enhance modeling efforts or influence planning decisions (Worboys 1994).

The spatial (location) and aspatial (attribute) data in a GIS database are used to address questions about the real world. In essence, the GIS database is a model of the real world that can be used to simulate certain aspects of reality. A model can be used to address questions about what exists now, what might exist in the future, as well as what existed in the past. All of these questions involve predictions that occur in time and space (Nichols 1997, personal contact).

PROJECT OBJECTIVES AND METHODS

The primary objective of this project was to implement a prototype ARC/INFO Arc Macro Language (AML) program to create a Graphical User Interface (GUI) (named Minlayer) to identify planning areas of concern in Licking County. Two case studies were developed to test the Minlayer GUI. The first case study, "Potential Sites for Conservation Tillage Practices on Potentially Highly Erodible Lands," focused on agricultural best management practices (BMPs) and surface-water quality concerns, looking specifically at conservation tillage. The second case study, "Potential Sites for Large-scale Development," concentrated on identifying potential sites for large, heavy, industrial, and commercial structures. The criteria chosen for each case study were based on information obtained from the planners, county reports, and the literature. Case study 1 criteria were selected from land-use/land-cover, slope, and soils coverages. Case study 2 criteria were selected from land-use/land-cover, groundwater-availability, and drainage classes. Table 1 lists the seven ARC/INFO coverages and their feature attributes.

The Minlayer GUI was designed to work within the IRIX 5.3 UNIX operating system. It is run on a Silicon Graphics Indigo2 workstation. Minlayer was designed using ARC/INFO AML version 7.03. This interface is comprised of automated steps to assist users in selecting coverages and transforming them to a base coverage that contains the desired features for each planning scenario under consideration.

TABLE 1

Case Studies: ARC/INFO coverages and feature attributes.

	Coverage	Feature Attributes
Case 1	Slope	212%
	Potentially Highly Erodible Lands	AfB, AhB, AmB2, BeB, BgB, BrC, CeB, CfB, ChB, ChC2, CkB, CoB, FrB, GfB, GnB, HoB, KeB, McB, MnB, OcB, RgC, TsB
	Land Use/Land Cover	cropland, pasture
Case 2	Groundwater Availability	100–500 gallons/minute yield
	Drainage Classes	moderately well and well drained
	Land Use/Land Cover	cropland, pasture, orchards and groves, nurseries, farmsteads, deciduous forests

Data Collection and Procedures

The data used in the case studies were obtained from a number of sources. The ARC/INFO coverages were originally digitized in a raster GIS and converted to a vector GIS by the Ohio Capability Analysis Program (OCAP) at ODNR (Bishop 1989). The land-use/land-cover coverage was developed by the Resource Analysis Section (RAS) at the ODNR. The criteria chosen from the land-use/land-cover coverage were cropland, pasture, orchards, nurseries, farmsteads, and deciduous forests. The land-use/land-cover coverage was classified to level four based on *The Ohio Land-use Land-cover Classification System* (Schaal 1988).

The slope coverage was developed from the Soil Survey of Licking County (1992). The slope criteria range was established between 2 to 12%, as suggested by the literature. The soils coverage was also derived from the Soil Survey of Licking County (USDA 1992), using the potentially highly erodible land criteria provided by the Licking County Soil and Water Conservation District.

The groundwater availability coverage was developed by the ODNR Division of Water (1982) and represents the groundwater characteristics of the county based upon the interpretations of over 8 000 water well records along with the local geology and hydrology. Selected records include areas that produce or are expected to produce 100 to 500 gallons per minute.

The drainage classes coverage was derived from the Soil Survey of Licking County, OH, and refers to the frequency and duration of saturation that exist on the soil (USDA 1992). The classes selected were moderately well and well drained.

ARC/INFO export files were created to transfer the original OCAP data over the Internet. The export files were imported into a format that was readable in ARC/INFO, and topology was constructed for the newly created coverages. Each coverage had to be projected into the same projection, in this case the State Plane Coordinate System (SPCS), Ohio South Zone. All of the coverages, except for the soils, were run through an AML program that matched the boundaries of the individual coverages to the boundary of the soils coverage.

Graphical User Interface Development and Implementation

Planners at Licking County were contacted and several discussions and meetings were conducted to determine specific planning needs and concerns about how GIS technology can be integrated in Licking County's management and planning efforts. Their primary interests were focused on land-use planning efforts that generate information regarding zoning codes and regulations for the townships. Considerable interest was also expressed in developing a GUI that could be used to quickly identify and display areas of concern. A specific interest was to develop a map of potential large-scale development sites that could be used for future zoning regulations. ODNR planners expressed similar interests, providing sample criteria that had been used in previous planning projects.

The development of the Minlayer GUI arose from a need expressed by the Licking County planners to address specific planning issues and reduce some of the time used to respond to public requests for information. The overall design of Minlayer emphasizes the reduction of poor land-use decisions that may be based on poor data or poor manipulation techniques. As a working tool, the Minlayer GUI allows users to identify, select, save, and display coverage features that help address planning concerns. The queries for which Minlayer was designed require a limited amount of working knowledge of logical operators. In two of the five modules (INPUT and OVERLAY), the user must use the logical operators 'and' or 'or'. Of course, Minlayer can be further refined to fit a specific planning concern.

Minlayer was developed using ARC/INFO's FormEdit and pulldown menuing systems (ESRI 1994). Minlayer is comprised of one pulldown menu and four FormEdit sub-menus, with the second, third, and fourth sub-menus using the coverages created in the previous menus. FormEdit menus utilize graphic widgets that dynamically define the action to be performed (ESRI 1994). FormEdit menus are designed to make Minlayer dynamic, making it possible to manipulate and display coverages in the same session. These menus consist of Button, Data List, Symbol List, Text, and Text Input widgets.

Minlayer prompts the user about the current workspace and provides the user with the opportunity to change the workspace. This step assumes that the user has write privileges for the present working directory. Once the workspace has been accessed, a list of coverages is displayed on the screen and-yn Arcplot graphics window is positioned in the upper right corner of the screen.

An ARC/INFO thread is created that runs the actual GUI, and the thread that started the ARC session is then deleted. A thread carries input from other AML programs, AML menus, or from the keyboard to the AML processor. The threads allow for the creation of an interface that guides the user through the application in a logical manner (ESRI 1994). This is a necessary step because an AML program such as ARC takes precedence over all other threads such as the GUI. Once the ARC thread is eliminated, the BMP menu is initialized.

The BMP menu consists of a pulldown menu that lists the four other sub-menus and a quit button (Fig. 1). This menu is the staging ground for the other sub-menus, and the order in which the sub-menus appear is the order in which they are designed to be run. However, the first sub-menu can be run before, during, or after the other sub-menus.

The first sub-menu listed is DISPLAY. In this sub-menu a list of coverages and their PAT (Polygon Attribute Table) items and values is provided. This sub-menu is designed to provide the user with a means to graphically portray the spatial relationships that exist between the coverage's features. The second sub-menu listed is INPUT. This sub-menu lists the coverage's PAT items and values and allows a user to save them to a new coverage that will be used in the OVERLAY sub-menu. The third sub-menu listed is OVERLAY. This sub-menu overlays

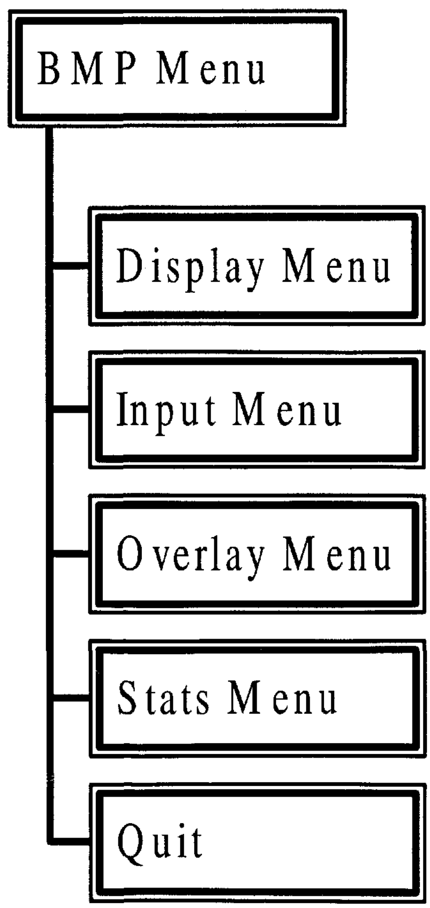

FIGURE 1. BMP Menu.

and intersects all of the polygons that were selected in the INPUT menu. This menu is used to produce a final coverage that contains only the user-defined PAT items and values of the individual coverages. The fourth sub-menu listed is STATS. This sub-menu is used to select the PAT items and values from the final overlaid coverage created in the OVERLAY menu, save them to a new coverage, and perform statistical manipulations.

RESULTS AND DISCUSSION

The spatial queries implemented in each case study allowed users to quickly access and inventory the available coverages in terms of the distribution and extent of criteria needed to address specific planning issues. In case study 1, the GUI was used to produce a coverage showing potentially highly erodible land, called sobufsites (Fig. 2), which identifies the soil map units that are borderline highly erodible and may have special management needs. The development of an approach to identify potential sites for large-scale development (Fig. 3) stemmed from planners' interests in a real-world application of the Minlayer GUI. The idea was to instantly identify locations that could support large-scale development based on the locational attributes such as soil type, area required, distance from water, distance from roads, and other zoning requirements. Planners and various Land Capability Analysis reports identified the essential coverages used in case study 2 (Table 1). The overall performance of the GUI was evaluated by professional planners associated with the land-

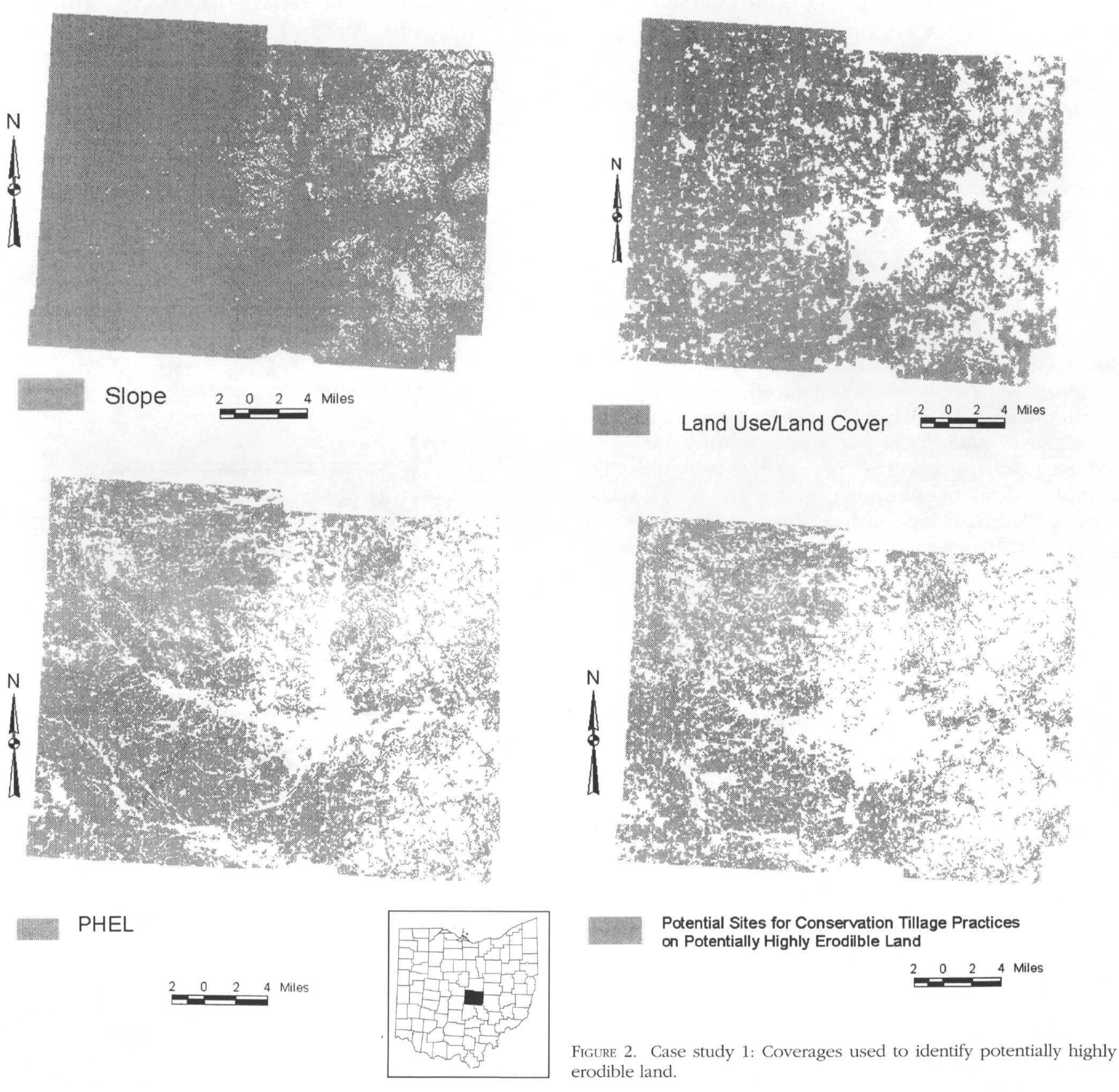

FIGURE 2. Case study 1: Coverages used to identify potentially highly erodible land.

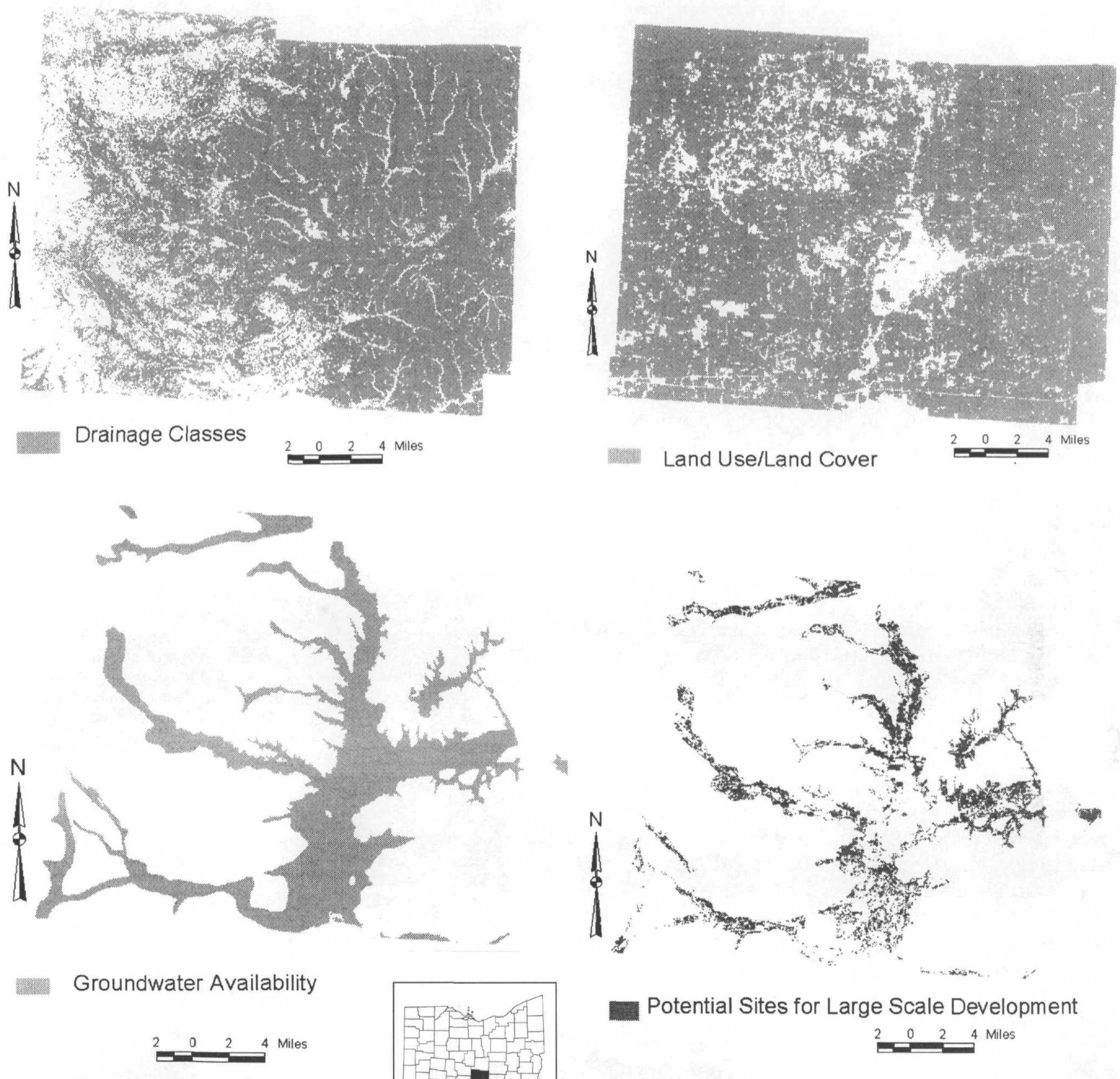

FIGURE 3. Case study 2: Coverages used to identify potential sites for large-scale development.

use planning concerns in Ohio.

Planners from the RAS at the ODNR expressed an interest in the initial application of this GUI. The planners provided input during the development and implementation of the GUI. Their participation and ideas were particularly helpful in refining the interface so that the final product consisted of a sequence of GIS operations relevant to the specific planning concerns addressed in this study. In each of the case studies, the planners ran the GUI and commented on the performance of the interface by making comparisons with experiences they had working on similar projects that used the manual techniques (command line) that were automated by the GUI. Based on their experience, the planners concluded that the GUI is more user-friendly and efficient than manual techniques. They also suggested alternative operations that could be used to accomplish similar tasks.

CONCLUSIONS

Planners have indicated interest in the applicability and flexibility of the GUI developed. The interface (Minlayer) has the potential to provide more functionality than just determining sites for potential large-scale development or vegetative filter strips and conservation tillage practices on potentially highly erodible land. This interface can be modified and used on other projects that involve land-use planning as well as other planning concerns such as watershed management. Such modifications will allow planners and modelers to select areas or points of concern as well as quickly identify the spatial components of locations which meet a user-specified criteria.

In the creation and development stages of the GUI, an important point to keep in mind is that the size of the coverages and the attribute data can significantly impact the processing time and speed of the operating system. This issue will become more apparent when the GUI is tested and implemented on various platforms other than the IRIX operating system in which the interface was originally developed. The issue of the operating system is particularly relevant when considering the technology currently available at the county level. Presently, Licking County planners do not have access to UNIX platforms or ARC/INFO version 7.03. Their operating systems are Windows based, and PC ARC/INFO 3.5 is the GIS software. The differences in the operating systems and the GIS software currently in use have resulted in a compatibility issue in terms of the programming language available. The GUI was developed using AML, a language that is not available for PC ARC/INFO. These types of issues must be considered when developing an interface.

In order to provide planners with a beta version of the GUI, the design will have to be modified so that the interface is compatible with the operating system and ARC/INFO version currently in use at the county level. After the planners have had time to become familiar with the GUI, feedback can be collected on its overall performance.

The value of the Minlayer GUI can be tested in various ways. A comparison between the outputs of the GUI and traditional methods can be used to determine whether or not the computerized method is an accurate approach. The amount of time and money invested to develop the final product can also be used as an evaluation method. A survey or questionnaire can be developed to determine if first-time users are comfortable with the GUI's design and to add some input on the overall layout and design of the GUI.

After the final coverages have been created, a geographic referencing layer should be added. This layer can consist of roads, a latitude-longitude graticule, or any other source of geographic referencing. This layer helps the ground-truthing step by locating and identifying areas that are created in the final coverages.

The flexibility of FormEdit and AML allows for easy modifications to be made on the Minlayer GUI. The GUI can be modified and further refined so that it works on specific overlay concerns. Modifying it to accept more data types will increase its overlay capabilities and provide users with a larger selection of data types. Overall, access and use of Minlayer supports efforts to develop management plans that reflect interactions at various scales.

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